

# Encounters between pairs of unfamiliar dogs in a dog park

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## Original Article

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**Introduction:** The aim of this study was to explore spontaneous social interactions between dyads of unfamiliar adult dogs. Although intraspecific encounters are frequent events in the life of pet dogs, the factors that might influence encounters, such as sex, dyad composition, reproductive status, age, and state of cohabitation (keeping the dogs singly or in groups), remained unexplored. **Methods:** In this study, we assigned unfamiliar, non-aggressive dogs to three types of dyads defined by sex and size. We observed their unrestrained, spontaneous behaviors in an unfamiliar dog park, where only the two dogs, the owners, and experimenter were present. **Results:** We found that the dogs, on average, spent only 17% of the time (less than 1 min) in proximity. Sex, dyad composition, reproductive status, and age influenced different aspects of the interactions in dyads. Female dogs were more likely to initiate the first contact in their dyad but later approached the partner less frequently, were less likely to move apart, and displayed less scent marking. Following and moving apart were more frequent in male–male interactions. Neutered dogs spent more time following the other dog and sniffed other dogs more frequently. The time companion dogs spent in proximity and number of approaches decreased with age. **Conclusion:** The study provides guidance for dog owners about the outcomes of intraspecific encounters based on the dog's age, sex, and reproductive status, as well as the sex of the interacting partner.

## INTRODUCTION

In Western societies, dogs live not only in the countryside but also in big cities and develop close relationships with humans (Miklosi, 2014). Dogs living in human households have owner-imposed daily routines that dictate times for eating, training, playing, and walking.

Walking has benefits for both owners and dogs. Owners have a tendency to spend more time in physical activity than people without dogs (Brown & Rhodes, 2006; Schofield et al., 2005; Serpell, 1991) and experience health benefits (Christian et al., 2016). In dogs, increased physical exercise and a socially stimulating and enriched environment have a positive effect on cognitive ability (Head et al., 2009; Milgram et al., 2005) and the quality of life (McMillan, 2002).

According to the UK Code of practice for the welfare of dogs (presented to the parliament pursuant to section 15 of the Animal Welfare Act 2006), “A dog needs regular exercise and regular opportunities to walk, run, explore, play, sniff and investigate.” “Owners should encourage their dog to be friendly towards other dogs and allow it to interact with friendly dogs on a regular basis.” However, the location of the walk or off-leash exercise, the length of the activity, and even the possible company of other dogs are dependent on the owner's preference, and are often dictated by the dogs' willingness to approach and interact with unfamiliar individuals (i.e., how sociable the individual is). The occurrence of positive interactions with conspecifics depends on the level of sociability of the individual dog and interaction partner, their degree of familiarity, and previous experiences both during and after the critical socialization period (Hubrecht et al., 2016; Sackett, 1991; Stevens, 2004). Consequently, the ability to recognize and understand the social behavior and communicative signals of family dogs during encounters with other dogs has great importance, in order to allow owners to provide intraspecific social enrichment and to select the most appropriate companions for their dogs.

Previous investigations examining intraspecific interactions were carried out in public open spaces where dogs were familiar with the area as well as one another

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(Carrier et al., 2013; Howse et al., 2018; Řezáč et al., 2011; Westgarth et al., 2010). Howse et al. (2018) found that most dogs interacted only briefly with each other, gradually lost interest over time, and importantly, the number of dogs interacting affected the dynamics of the interaction. They observed that the number of greetings received for each dog increased with group size, while avoidance behaviors were most frequent for intermediate group sizes. These findings show that for any given dyad of interacting dogs, the presence of additional dogs could be a confounding factor.

Another observation by Howse et al. (2018) was that males scent-marked more frequently than females. Although they only found effects of sex on elimination behavior, it is possible that potential behavioral differences between male and female dogs play a greater role during initial encounters in novel environments and among unfamiliar dogs, lacking established relationships with clear set boundaries and hierarchies. Both theoretical (Decety, 2011) and empirical works suggest that across mammals, social behavior and cognition might be sexually dimorphic, with females often performing better in social tasks (Bartal et al., 2011; Connellan et al., 2000; De Waal, 1996; Lutchmaya et al., 2002). It can be expected that some of the putative differences in social behavior will play a substantial role in spontaneous first encounters. Among humans, for instance, women have been reported to be more extrovert (Weisberg et al., 2011), a trait that can crucially shape first contacts; regarding the human literature, this effect might depend on how extraversion is operationalized. Some evidence for sexual dimorphism has already been found in dogs regarding personality traits, with female dogs being more sociable, but less bold (Kubinyi et al., 2009). A higher sociability among female dogs was also supported by higher initiation of play bouts, observed in all-female dyads (Bauer & Smuts, 2007). Moreover, sexual dimorphism is known in dogs to also concern non-social cognition, such as the perception of object permanence (Müller et al., 2011) and verbal learning (Iotchev et al., 2017).

The sex composition of dyads can play a role due to different dynamics between and within the sexes. For example, in free-ranging dog packs, greater aggression between female pack members was reported (Pal et al., 1998), but female pet dogs were also found to play more frequently (Bauer & Smuts, 2007). In mixed-sex dyads, we can expect that an asymmetrical mating interest, which is greater on the male part, might affect the interactions (Beach & LeBoeuf, 1967; Cafazzo et al., 2014; Ghosh et al., 1984; Scott, 1950).

Dogs' reproductive status can affect a variety of behaviors, including marking, mating, aggression, and activity levels. However, some findings contradict each other, which suggest that the age of spaying has a confounding effect (Heidenberger & Unshelm, 1990; Le Boeuf, 1970; Lisberg & Snowdon, 2011; Salmeri et al., 1991). According to Heidenberger and Unshelm (1990), in neutered dogs, social activity, specifically play behavior and persistence, increases, whereas general activity was found to decrease as indicated by increased resting time and lower motivation to move.

As dogs undergo a double socialization to both humans and dogs (Miklósi, 2014), we expect communicative

behaviors to be different for dogs living together with conspecifics versus those who only share the home with a human caretaker. Although the differences might be subtle, higher exposure, more efficient intraspecific socialization can be expected for dogs that live with other dogs.

Age can also be expected to affect social behaviors in dogs (Howse et al., 2018; Rosado et al., 2012). Social rank is likely to change with age (Bonanni et al., 2010, 2017; Cafazzo et al., 2010; Pal et al., 1998), which might affect at least some social behaviors like observational learning (Pongrácz, 2014; Pongrácz et al., 2008) and leadership (Ákos et al., 2014).

In this study, our aim was to explore spontaneous social interactions between dyads of unfamiliar adult dogs. The animals were chosen to be at least 3 years of age, because in a few breeds, sexual maturation can take up to 2 years. In particular, the goal was to examine the effects of sex, dyad composition, reproductive status, age, and state of cohabitation (keeping the dogs singly or in groups). To our knowledge, the factors that might influence spontaneous behaviors displayed during encounters with unfamiliar dogs in unfamiliar environments are yet to be investigated. In addition, because these animals had never met before, no social structure existed that might have influenced other findings on dog–dog interactions in the past (e.g., Howse et al., 2018). Therefore, it is still an open question to what extent and how dogs will attempt to socialize under these circumstances.

Dyad composition was defined by the sex and size of the dogs, which were assigned to another dog of the same size and same or a different sex resulting in an equal number of all-male, all-female, and mixed-sex dyads. There was however no balancing for reproductive status or cohabitation. Behaviors that reflect social interest (approach, avoidance, and following), tolerance (proximity), and communication (sniffing and scent marking) were recorded over a 5-min period, with the aim of examining the factors that may be associated with the behaviors, in a setting where novel social and non-social stimuli compete for the animal's attention.

## METHODS

### Subjects

Thirty-six dogs [12 from mixed breeds; 24 from pure breeds (19 different breeds); male:female = 1:1, mean age  $\pm$  SD =  $6.5 \pm 2.63$  years] were recruited for this study. Only dogs that usually did not display any kind of intraspecific aggressive behavior according to the owners were selected to participate in the study. Owners filled in a questionnaire regarding the sex, age, breed, reproductive status, origin, and cohabitation with other dogs prior to the actual experiment and the information is summarized in Table 1.

### Protocol

The experiment took place in a fenced area (approximately 200 m<sup>2</sup>), including several objects (trees, bench, and playground accessories), which was unfamiliar to the dogs and their owners, in Hamm, Germany. The dogs were assigned to 18 dyads, with one third of the dyads (6 dyads)

Table 1. Dogs' demographic data

Dyad ID	Dog's name	Age (years)	Sex	Breed	Cohabitation
1	Azana	7	Female	Rhodesian Ridgeback	Group
1	Lennox	5	Male	Great Dane	Group
2	Maya	8	Female*	Mix	Group
2	Frida	7	Female*	Miniature Bull Terrier	Single
3	Laica	7	Female*	Mix	Single
3	Olaf	4	Male	Mix	Single
4	Flavio	9	Male	Galgo	Group
4	Flash	8	Male	Dalmatian	Group
5	Shiro	5	Male	Galgo	Group
5	Sammy	11	Male	Mix	Group
6	Shanty	4	Female*	Chinese Crested	Group
6	Tess	7	Female*	Pinscher	Group
7	Koda	3	Male*	Chinese Crested	Group
7	Jerry	5	Male	Mix	Group
8	Paul	9	Male	Labrador	Group
8	Davee	3	Male*	Border Collie	Group
9	Arin	8	Female*	Mix	Single
9	Ace	10	Female*	Border Collie	Group
10	Pepper	12	Male	Beagle	Group
10	Schröde	3	Male	Mix	Group
11	Luna(1)	4	Female	Mix	Group
11	Bolle	6	Male*	Kromfohrlander	Single
12	Ida	4	Female	Appenzeller Sennenhund	Single
12	Eddy	9	Male*	Border Collie	Group
13	Emma(1)	10	Female	Mix	Single
13	Titus	7	Male*	Mix	Single
14	Edelbär	3	Male*	Schnauzer	Group
14	Snoopy	4	Male	Mix	Single
15	Luna(2)	9	Female*	Maltese	Single
15	Bari	4	Female*	Whippet	Single
16	Emma(2)	4	Female	Boxer	Single
16	Lizi	9	Female*	Mix	Single
17	Lee	5	Female*	Pinscher	Group
17	Nemo	10	Male*	Schnauzer	Group
18	Berta	3	Female*	Bulldog	Single
18	Amber	8	Female*	Dutch Shepherd	Group

Note. Neutered dogs are marked with \*, dogs that participated in all-male dyads are shown in dark-gray background, and those in all-female dyads in light-gray background.

comprising a mixed-sex group and the other two third being all-male and all-female dyads (6 dyads in both cases), respectively (Table 1). Owners who were about to participate were instructed to keep their dogs in the owner's car until it was their turn, to avoid premature contact between the animals. Data were collected with a video camera by the experimenter. Each recorded session began when two dogs assigned to the same dyad were unleashed, simultaneously, inside the fenced area, at a distance of 5–10 m from each other. Owners were neither allowed to carry potentially distracting toys or food with them, nor to touch or talk toward their dogs directly during the session, unless to separate them in case of a fight. Owners were allowed to walk around and communicate with the other owner. Because the owners were not always visible in the recording, their behaviors were not coded. The session ended after 5 min had elapsed.

#### Behavioral variables

Unless in interactive distance, the two dogs were usually not visible simultaneously on the video recording. Due to these limitations, we restricted all our observations to interactions in proximity. Proximity was defined as less than two dog lengths (accounting for the size of the interacting partners).

1. Latency to first approach: the time (s) between the unleashing of dogs and the dogs being in proximity.
2. Time (s) spent following the other dog: a dog was coded as following the other dog if it actively maintained proximity, while the other dog was moving independently.
3. Time (%) spent in proximity: seconds spent in proximity/300 s (5 min, the total duration of a session).

4. Which dog initiated contact first: a dog was marked as the first initiator if its latency to first approach was shorter than that of the other dog in the dyad.
5. The number of times a dog approached the other dog: an approach was coded every time a dog decreased distance to the other dog until they were in proximity (as defined above). An approach was scored for each dog in the dyad if it was mutual.
6. The number of times a dog moved away from the other dog: a parting was scored if a dog increased distance until proximity (as defined above) was no longer present. Only one of the dogs was scored as moving apart, if the other dog was not moving or moving significantly slower, otherwise both dogs were scored as parting.
7. The number of times a dog sniffed the other dog: sniffing was scored when the nose was <5 cm from the body of the partner.
8. The number of times a dog urinated.
9. The number of times the dog defecated.
10. The number of times the dog displayed a play bow.
11. The number of aggressive events: growling and chasing away.

#### Statistical analysis

The main effects of age, sex, reproductive status, state of cohabitation, and dyad composition were tested for each variable using a generalized linear model (GLM). Only latency to first approach was tested using Cox regression, which is the recommended analysis for testing latencies to events of interest. Relationships between any two binary variables were investigated with a z-test. No interactions were analyzed due to the sample size. For time spent in proximity, the value was equal for each dog in a given pair; therefore, we only set the type of dyad and the dyad's mean age as predictors, since averaging reproductive status or cohabitation is not meaningful, but factors defining the dyad as a whole are. All analyses were carried out in SPSS, version 22.0 (Armonk, NY, USA). The assumed distribution of the dependent variables was chosen to be gamma for durations (Aitchison, 1955; Firth, 1988) and loglinear for variables representing frequencies of expressed behaviors (Holland & Thayer, 2000) in cases where normality assumption for the residuals was violated (Kolmogorov–Smirnov test of normality). Otherwise, we assumed a normal distribution. The model's covariance matrix was calculated with robust estimation due to the relatively small sample. In case of non-parametric testing, the hybrid method was used for this calculation. Model fitness was increased with backward elimination and the Akaike information criterion, that is, non-significant predictors were removed from the model until the lowest absolute Akaike value was reached, but put back into the model if the value increased again with their elimination.

#### Behavioral coding and reliability

Two observers coded the behavioral variables for all 18 dog pairs using Solomon Coder [beta 091110, developed by András Péter (copyright 2006–2008)]. We evaluated the interobserver reliability using two-way random intraclass

correlation (ICC), looking for absolute agreement between average measures.

Agreement was significant for all duration/latency variables: the time spent in proximity ( $p < .001$ , ICC = .980), the latency to first approach ( $p < .001$ , ICC = .708), and the time spent following the other dog ( $p < .001$ , ICC = .967).

Agreement was also significant for most frequency variables: which dog initiated contact first ( $p < .001$ , ICC = .756), the number of approaches ( $p < .001$ , ICC = .926), the number of times a dog actively moved away from the other dog ( $p < .001$ , ICC = .888), the times a dog sniffed the other dog ( $p < .001$ , ICC = .868), the number of times a dog urinated ( $p < .001$ , ICC = .856), and defecated ( $p < .001$ , ICC = .703) while in the proximity of the other dog. Agreement was not significant for the expression of play bows ( $p = 0.058$ , ICC = .420); therefore, it was omitted from further analysis. An aggressive event was observed only once and did not escalate to a fight. This variable was therefore also not analyzed.

## RESULTS

Dogs on average spent  $17.31\% \pm 2.0\%$  (mean  $\pm$  SE) of the time in the proximity of the other dog. The type of dyad had no effect on the percentage of time spent in proximity (GLM, Wald  $\chi^2 = 1.471$ ,  $p = .479$ ), but time spent in proximity decreased with a dyad's mean age (GLM, Wald  $\chi^2 = 13.152$ ,  $p < .001$ ; Fig. 1A).

We next tested how age, sex, reproductive status, state of cohabitation, and dyad composition were associated with latencies to first approach and time spent following the other dog. The latency to first approach was not associated with any of the investigated factors ( $p > .1$  in the final model). The final model for time spent following (the other dog) included cohabitation, dyad type, and reproductive status as fixed effects. Time spent following was affected by the type of dyad (Wald  $\chi^2 = 10.254$ ,  $p = .006$ ). In all-male dyads, dogs followed each other longer than in mixed dyads (Wald  $\chi^2 = 4.633$ ,  $p = .032$ ; Fig. 1B). Other pairwise comparisons were not significant ( $p > .07$ ). Reproductive status also significantly predicted time spent following (GLM, Wald  $\chi^2 = 8.995$ ,  $p = .003$ ). Neutered dogs followed the other dog longer compared to intact dogs (Wald  $\chi^2 = 5.978$ ,  $p = .014$ ; Fig. 1C). There was a trend for cohabitation to predict time spent following (Wald  $\chi^2 = 3.546$ ,  $p = .06$ ), but no significant difference was confirmed for singly versus group-kept dogs post-hoc (Wald  $\chi^2 = 2.147$ ,  $p = .143$ ).

We observed that 89% of female dogs and 56% of male dogs initiated the first contact in their dyad (z-test significant under the  $p < .05$  criterion). Looking at the distribution of this behavior of dogs of different reproductive status, we found 63% of intact dogs to initiate the first contact versus 80% of neutered dogs (z-test,  $p > .05$ ).

Next, we investigated how age, sex, reproductive status, state of cohabitation, and dyad composition affect approach and avoidance behaviors. The final model for investigating the number of approaches included the predictors age and sex. The number of approaches a dog initiated declined with



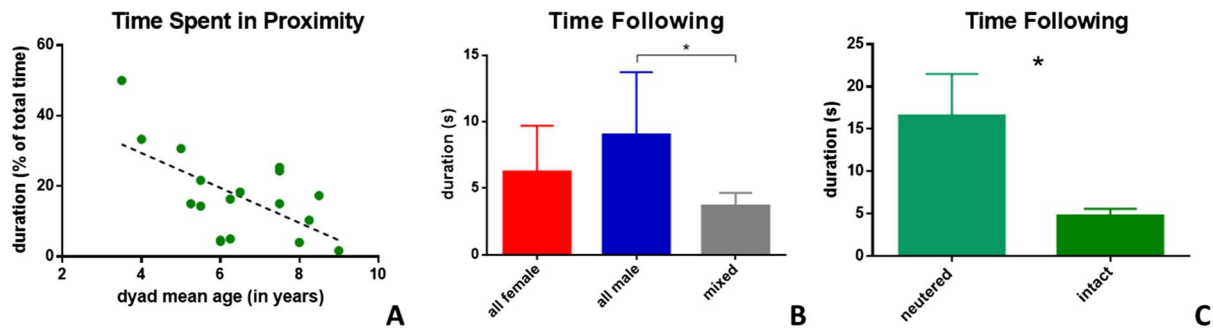


Fig. 1. (A) Time spent in proximity as a function of dyad mean age; (B) Means and standard errors for the time spent following the other dog for each dyad composition; (C) Means and standard errors for the time spent following the other dog in neutered and intact dogs. Significant results are marked with  $*p < .05$

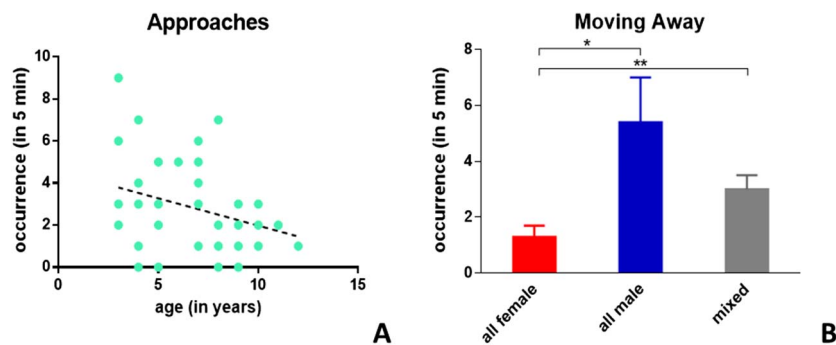


Fig. 2. (A) Number of approaches as a function of age; (B) Means and standard errors for the number of times a dog moved away from the other dog for each dyad composition. Significant results are marked with  $*p < .05$ .  $**p < .01$

age (GLM, Wald  $\chi^2 = 4.958$ ,  $p = .026$ ; Fig. 2A) and there was a trend for an effect of sex (GLM, Wald  $\chi^2 = 3.328$ ,  $p = .068$ ). Male dogs approached the other dog more often, but the effect remained marginally significant post-hoc (Wald  $\chi^2 = 3.328$ ,  $p = .068$ ).

The final model for the number of times a dog actively moved away from the other dog included the fixed effects: dyad composition, state of cohabitation, sex, and age. However, the number of times a dog moved away from the other dog was only significantly associated with dyad composition (GLM, Wald  $\chi^2 = 9.955$ ,  $p = .007$ ). Dogs from all-female dyads moved apart less often than dogs from all-male dyads (Wald  $\chi^2 = 12.054$ ,  $p = .018$ ) and dogs from mixed dyads ( $p = .003$ ;  $1.3 \pm 0.4$  times in 5 min vs.  $3 \pm 0.5$  times in 5 min; means  $\pm$  SE). There was no difference between all-male and mixed dyads ( $p = .162$ ; see Fig. 2B for overview). There was a trend for the state of cohabitation to affect moving away (GLM, Wald  $\chi^2 = 3.76$ ,  $p = 0.052$ ), with dogs kept singly moving apart more often ( $p = .048$  or the mean difference, which is 1.42). There was also a trend for an effect of sex (GLM, Wald  $\chi^2 = 3.438$ ,  $p = .064$ ). Female dogs moved away more often than males (Wald  $\chi^2 = 3.146$ ,  $p = .076$ ). Age did not affect moving apart (GLM, Wald  $\chi^2 = 2.348$ ,  $p = .125$ ).

The final model for sniffing behavior included the fixed effects: reproductive status, dyad type, and age. Sniffing behavior was associated with reproductive status (GLM, Wald  $\chi^2 = 7.969$ ,  $p = .005$ ). Neutered dogs sniffed the other dog more frequently than intact dogs (Wald  $\chi^2 = 6.987$ ,  $p = .008$ ; Fig. 3). However, age did not predict sniffing behavior (GLM, Wald  $\chi^2 = 1.424$ ,  $p = .233$ ) and neither did dyad type (GLM, Wald  $\chi^2 = 2.528$ ,  $p = .283$ ).

Due to zero inflation, we could not analyze the data concerning marking behavior (urination and defecation). Only 12 dogs (33.3% of the sample, 11 males) marked with urine and of these only 8 dogs (22.2% of the sample) urinated more than once. Interestingly, the behavior was not observed in any dyad consisting of two females, but eight of the dogs who marked with urine were from all-male dyads (66.7% of all urinating dogs, the remaining dogs were from mixed dyads). Only four dogs (33.3% of all dogs who urinated) were kept singly. Defecation was displayed by only five dogs (13.9% of the sample, three males), each of them displayed the behavior only once.

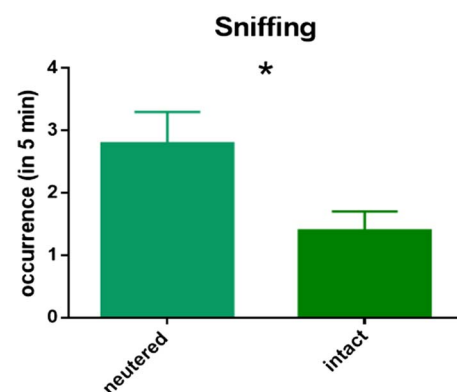


Fig. 3. Means and standard errors for the number of times a dog sniffed the other dog in neutered and intact dogs. Significant results are marked with  $*p < .05$

## DISCUSSION

This study investigated dogs' spontaneous responses to unfamiliar dogs upon their first encounter. We report that sex, dyad composition, reproductive status, and age are related to different aspects of intraspecific interactions. We will discuss in more detail the specific implications of the results, separately for each of the investigated predictors and close the discussion with a look at how this study compares to more conceptually similar work (spontaneous social behavior with minimal experimental manipulation), as well as relevant limitations as follows.

*Sex differences and dyad composition*

We found that female and male dogs differ in several behavioral measures. Females moved apart less from each other, did not scent mark by urination, and more female dogs initiated the first contact in their dyad. Higher social initiative in female dogs also previously also observed by Bauer and Smuts (2007) who reported that females play more frequently with each other than males.

Sexual differences observed in dogs span across a broad variety of measures. Object-permanence perception appears to be better in female dogs (Müller et al., 2011) and female dogs appear to benefit more from sleep-dependent learning, associated with a higher incidence of sleep spindles (Iotchev et al., 2017). Sexual dimorphism concerning physiology and/or behavior is relatively widespread in mammals (Bartal et al., 2011; Decety, 2011; De Waal, 1996; Woodward & Bauer, 2007), likely due to both sexual selection (Darwin, 1871) and ecological factors (Shine, 1989; Slatkin, 1984). It is particularly well established in humans, where it is observed as early as the neonatal developmental stage and appears to rest at least in parts upon our biological makeup. More specifically, it was found that levels of fetal testosterone predicted eye-contact behaviors in infants postnatally (Connellan et al., 2000; Lutchmaya et al., 2002). Higher social initiative in female dogs might relate to humanlike sex differences in personality. When the classical "Big Five" dimensions of personality are divided along two aspects each (Weisberg et al., 2011), women score higher on extraversion, provided that the sociability aspect is more emphasized than the assertive aspect. Similarly, in dogs, females were found to be more sociable, but they were less bold (Kubinyi et al., 2009).

However, the relationship between sex and behavior in dogs might not always be a straightforward one. A specialized breeding history may result in more homogenous behavior across individuals, masking the species' natural tendencies for behavioral dimorphism. Accordingly, a previous study found that female dogs looked longer at pictures of unfamiliar faces only among mixed-breed dogs (Bognár et al., 2018). Moreover, a recent meta-analysis of the literature on canine sexual differences (Scandurra et al., 2018) suggests that sex differences in social engagement, at least in dog-human interactions, are likely context-specific. Female dogs preferentially engage with human partners in cooperative tasks, whereas male dogs are more likely to engage in social play.

We observed that moving away from the other dog was more prevalent in mixed dyads than all-female dyads and there was a trend for females to move away more frequently than males. This might be related to canine mating dynamics, which are characterized by a more persistent (throughout the year) sexual interest on the males' part (Scott, 1950) and also by more selective and avoidant behavior on the part of the females (Beach & LeBoeuf, 1967; Ghosh et al., 1984), in particular toward intimidating and low-ranking males (Cafazzo et al., 2014).

Males, however, also preferred to move apart in all-male dyads more frequently than females in all-female dyads. The amount of time spent following the other dog was higher in all-male dyads than in mixed dyads. The results suggest that male dogs engaged in a series of short, but frequent contacts with each other. This dynamic might relate to the higher boldness and lower sociability previously reported for male dogs (Kubinyi et al., 2009).

Sex also played a role in scent marking, which in canines serves at least the function of marking territorial borders and signaling sexual status (Cafazzo et al., 2012; Lisberg & Snowdon, 2011; Mech & Boitani, 2003). It can, however, also act as a display of dominance or social challenge among both wolves and dogs (Asa et al., 1990; Cafazzo et al., 2012). There is some evidence that scent marking can even indirectly communicate information like body size without direct interaction (McGuire & Bemis, 2017; McGuire et al., 2018).

All-female dyads displayed no urination and only one of the 12 dogs, which displayed this behavior, was female. This squares with other findings showing that males engage more frequently in marking behavior (Beach, 1974; Bekoff, 1979; Howse et al., 2018; McGuire & Bemis, 2017; Pal, 2003).

*Reproductive status*

Spaying/neutering (or gonadectomy) influences the behavior of animals through complex interactions with their endocrine hormonal systems. To date, in dogs, there is evidence for changes in marking behavior (Lisberg & Snowdon, 2011), sexual behavior, and aggression (Heidenberger & Unshelm, 1990; Le Boeuf, 1970), as well as levels of activity/locomotion (Heidenberger & Unshelm, 1990; Salmeri et al., 1991).

We found neutered dogs to engage more frequently in sniffing the other dog and following it over longer periods of time. This could be an effect of increased social activity in neutered dogs (Salmeri et al., 1991). Activity has been reported to increase specifically for the domains of play and social interaction (Heidenberger & Unshelm, 1990), but not general activity in neutered dogs. In this study, actual play was observed in very few dyads and the interobserver agreement was low; therefore, we did not analyze this behavior.

*History of cohabitation*

A trend for a more frequent display of moving away from the other dog was observed for singly kept dogs. Various studies report effects of early social isolation on human and animal social skills and behavior (Burrows et al., 2017;

Harlow et al., 1965; Lykken, 1994; Wongvitdechcha & Marsden, 1996). In pet dogs, we can expect that social competence with regard to conspecifics can be selectively affected by limited exposure to other dogs. Our results suggest that living in a multiple-dog household produces observable differences in spontaneous interactions.

### *Effects of aging*

The study of aging dogs has recently gained a lot of attention (Chapagain et al., 2018; Mongillo et al., 2013; Wallis et al., 2016), both due to the dog's potential as a model animal (Adams et al., 2000; Araujo et al., 2005; Cummings et al., 1996) and to expand veterinary applications (Landsberg et al., 2003).

We found that both time spent in proximity to an unfamiliar dog and the number of approaches decreased with age. Previous work has reported that aging and in particular pathological aging could affect social responsiveness in dogs (Howse et al., 2018; Rosado et al., 2012), although it is difficult to separate these observations from a general decline in activity. In addition, age also correlates with social rank in canines (Bonanni et al., 2010, 2017; Pal et al., 1998). Social rank by itself has been shown to affect some social behaviors, for example, social learning across several species (Nicol & Pope, 1999; Pongrácz, 2014), but also active versus passive approach to social interaction (Schenkel, 1967), with dogs of higher rank being often the recipients rather than initiators of ritualized greetings (Bonanni et al., 2010). It was also observed that younger dogs initiate more muzzle contacts (Howse et al., 2018) further strengthening the notion that higher age and/or rank are associated with being more passive in social interactions. To date, only playful pursuits and attacks were frequently observed in older dogs and strictly concerned relative age differences within dyads of playing animals (Bauer & Smuts, 2007). Whether or not mediated by social rank, an association between age and social responsiveness/interest in a naturalistic setting is a valuable observation, as it adds to similar observations obtained under laboratory conditions (Rosado et al., 2012).

### *Relation to similar studies and limitations*

A role of age and sex in dogs' spontaneous social behavior was also reported by Howse et al. (2018) as well as Bauer and Smuts (2007), who employed a similar dyadic setup, but in both studies the focus is different from ours. Bauer and Smuts (2007) concentrated more specifically on play behavior, which was close to absent in this study, and their results and discussion deal exclusively with the behaviors expressed during play, as well as the duration and frequency of play bouts. Meanwhile, Howse et al. (2018) worked with mutually familiar dogs and investigated various group sizes. Their study did not investigate the effect of keeping condition, which we found to be marginally associated with moving away from the other dog. In terms of results, neither study detected a linear drop of time spent in proximity with age. This was not inquired in Bauer and Smut's work (2007), whereas Howse et al. (2018) analyzed individual dogs, observing a quadratic relationship: middle-aged dogs

invested the least time in contact with other dogs. Our observation, on the other hand, was for dyads, not individuals. There was also no report of sex effects on first contact initiation in either study.

We found that pairs of unfamiliar, unaggressive companion dogs spend around 1 min in the proximity of each other and 4 min in exploring the novel environment within a 5-min period, which suggests that levels of social interest and proximity seeking are generally relatively low in unfamiliar adult dogs. Howse et al. (2018) found even familiar dogs to interact over relatively short periods of time.

Potential limitations of the study include the relatively small sample size that, at the very least, limited our statistical exploration of scent marking (partly also due to a very low frequency for that behavior). The implications of the descriptive statistics can and should be complemented in future studies by inferential statistics on larger samples. The sample size was also a limiting factor with regard to testing potentially interesting interactions; however, due to the properties of generalized linear models, the estimates of all main effects are adjusted for each other, such that our results indirectly account for interactions. Again, larger samples in the future could more explicitly shed light on what putative interactions look like.

Our prescreening limits the external validity of our findings to dogs with relatively unproblematic social behavior. Potentially relevant knowledge for managing more problematic dogs could and should be obtained with more inclusive data sets in the future.

## CONCLUSION FOR FUTURE BIOLOGY

Until recently, much of what we knew about the body language and social behavior of dogs and the closely related wolf was derived from field observations in feral dogs and captive wolves (Bonanni et al., 2010, 2017; Cafazzo et al., 2014; Pal et al., 1998; Schenkel, 1967; Zimen, 1981). The companion dog, on the other hand, was mostly approached with rigid experimental setups and studies investigating its spontaneous social behavior under natural conditions are to date fewer in comparison and more recent overall (Ákos et al., 2014; Howse et al., 2018; Smuts et al., 2016; Trisko & Smuts, 2015; Van Der Borg et al., 2015). The current preliminary investigation presents a continuation to the latter line of research, which aimed to provide conditions allowing free exploration and interaction, while introducing experimental manipulations only with regard to dyad composition.

The study could provide guidance for dog owners about the possible outcomes of encounters depending on the characteristics of their dogs. Although our findings do not generalize to dogs with recognizable aggression problems due to prescreening the participants, the findings can yet be helpful in forming realistic expectations, correctly classifying behavior as normal and/or healthy, thereby efficiently manage and arrange dog–dog encounters. In particular, we provide empirical evidence for the level of activity, social interest, and the expression of approach/avoidance behaviors that can be expected based on the dog's age, sex, and reproductive status, as well as the sex of the interacting partner.

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**Ethical Statement:** The procedures applied complied with national and EU legislation and institutional guidelines. The study received ethical permission from the Eötvös Loránd University, Budapest, Hungary (permission no.: PE/EA/2019-5/2017). Owners provided written consent to their participation. Our consent form was based on the Ethical Codex of Hungarian Psychologists (2004). We took special care to ensure that the consent process was understood completely by the dog owners. In the consent form, participants were informed about the identity of the researchers, the aim, procedure, location, expected time commitment of the experiment, the handling of personal and research data, and data reuse. The owners were not informed about the exact aim of the test. The information included the participant's right to withdraw their consent at any time. Participants could at any point decline to participate and could request for their data not to be used and/or deleted after they were collected during the experiments. The study was performed strictly in accordance with the recommendations in the International Society for Applied Ethology guidelines for the use of animals in research.

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**Authors' Contributions:** IBI contributed to final behavioral coding, statistical analysis, and writing. AE contributed to final behavioral coding and writing. SG contributed to preliminary behavioral coding and data collection. AA contributed to writing. EK contributed to preliminary behavioral coding and writing.

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